TECHNICAL SUMMARY

Study Title: Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies

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Contract Number: 01-02-CT-85139

Sponsoring OCS Region: Headquarters–Sand and Gravel Unit, Leasing Division

Applicable Planning Areas: East and Gulf of Mexico Coasts

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Background: The Minerals Management Service (MMS) is charged with environmentally responsible management of Federal Outer Continental Shelf sand and gravel resources, that is, those resources lying seaward of the State/Federal boundary. MMS has responsibility for providing environmental analysis and assessment information enabling the responsible management of the OSC sand resources. There is a range of environmental concerns, including both direct and indirect impacts, with the dredging operations necessary for sand borrow extraction. This project was initiated to evaluate the extent to which recent developments in offshore dredging equipment and practices may lead to more environmentally friendly results.

Objectives: The goal of the project is to evaluate dredging equipment and techniques on a worldwide basis to identify existing and emerging dredging technologies that aim to reduce or avoid potential adverse effects on the offshore biological and physical environment. Based on the results, recommendations are developed for an implementation strategy for any promising technologies.

Description: The focus was primarily on Trailer Hopper Suction Dredges as these are the most likely vessels of choice for dredging operations where the borrow deposit and the project site requiring the sediment are several kilometers or miles apart. However, in some cases Cutter Suction Dredges and Dust Pan Dredges may also be utilized so these have also been considered.

Twelve key impacts were identified and prioritized through discussions with the Federal and State resource agencies that are actively dealing with dredging impact issues. Of the twelve impacts identified, a short list was developed for detailed investigation by focusing on those issues which were not being actively investigated through other MMS or other agencies, and which did not have sufficient existing MMS stipulations. In order of priority ranking based on discussions with the resource agencies in the US, the short list included: Direct loss of entire benthic communities and possible re-colonization by an altered biological community; changes in the substrate characteristics (grain size, dissolved oxygen, compaction and organic content) that lead to a reduction in benthic communities and suitability of the area for future dredging; sedimentation (burial) impacts to adjacent hard/live bottom or other sensitive habitats; and, impacts from short-term increased turbidity from cutterhead or draghead and overflow from hopper dredges on benthic communities. Other key concerns such as impacts to turtles, shoreline impacts through changes to wave climate, spatial and seasonal conflicts with recreational and commercial fishermen, potential damage to pipelines, damage to archeological resources, and potential harmful alteration or destruction of Essential Fish Habitat are being or have been recently addressed in other MMS (and US Army Corps of Engineers in the case of sea turtle impacts) studies. The impact to Essential Fish Habitat was discussed in a preliminary manner during the project workshop and some other recommendations were developed. The existing stipulations for collision with marine mammals were determined to be sufficient.

A review of the range of existing and emerging environmentally friendly techniques and approaches to dredging was supported by a literature review and an industry survey. The industry survey included both US and European dredging contractors. In general, this review found that the US dredging industry is not lagging the European market in development of innovative approaches. Two of the key recent developments to address dredging impacts in offshore waters, and particularly the size and extent of dredge plumes, consisted of the use of an anti-turbidity valve to reduce air entrainment in the overflow process and an approach of re-circulating the overflow water to the draghead (a “closed system” sometimes referred to as “Green Pipe”), eliminating the plume from the upper part of the water column. Both the European and US dredging industries had adopted widespread use of the anti-turbidity valve. Neither the European nor US dredging industries had adopted the closed system approach to overflow due to capital and operational costs and lack of justification to eliminate overflow in the upper part of the water column. Another approach that is becoming universally adopted, at least within the US market where aggregate dredging and screening are not carried out, is below hull release of the hopper overflow. This approach also reduces the size of the turbidity plume.

The key area of difference between the US and European dredging industries was the size of hopper dredges. Within a decade in Europe the maximum hopper size of Trailing Suction Hopper Dredges has moved from around 12,000 m^3 to in excess of 35,000 m^3. In contrast, in the US, the largest hopper dredges are the Great Lakes Dredge & Dock Liberty Island (5,000 m^3) and Bean Stuyvesant (8,360 m^3). With respect to dredging impacts, the primary implication of this difference is that almost all of the recent research on hopper design (and efficiencies related to the overflow process) has been completed in Europe. However, US dredging contractors ultimately benefit from these developments.

There has also been a tremendous amount of development in dredging equipment related to controlling the release of sediment at the dredge head, particularly for projects involving the removal of contaminated sediments. These techniques were reviewed and discussed as part of this project but do not really contribute to the evaluation of issues and techniques appropriate for most OCS dredging operations.

From the industry survey and the literature review it was apparent that most approaches and equipment development has focused on reducing turbidity levels associated with overflow from hopper dredges. These various efforts have reduced the sedimentation footprint associated with the overflow plume to extending no more than about 200 m beyond the dredge area, at least at locations where ocean currents are not strong. The success of concentrating the overflow plume may be leading to a new problem, at least in some cases, and that is the development of a near bed turbidity current. In these cases, a turbidity current consisting of a highly sediment-laden flow can travel 100's of meters up to several kilometers away from the borrow deposit, significantly expanding the area of impact. Turbidity currents are triggered under certain conditions consisting of a steep seabed slope and/or strong currents (with the dredge operating in line with the currents).

Very little if any development in either equipment or dredging approaches has been devoted to the key issue of loss of benthic communities. Some possible approaches, consisting of setting aside spatial or temporal refuges, were developed by the study team for further evaluation. In other cases, where environmentally friendly approaches or equipment had not been developed to address particular key impacts, some suggestions were generated by the team members for further evaluation.

The study workshop formed the final phase of the investigation and was attended by representatives of: the study team, MMS, US Army Corps of Engineers, and the dredging industry. For each type of equipment, procedure or approach that was reviewed, the evaluation was completed for three criteria: appropriateness, practicality and effectiveness. The recommendations are summarized in the following paragraphs for each of the key impacts.

It is may be appropriate, practical and effective to impose spatial or temporal refuge areas at locations with one or more of the following characteristics: 1) the presence of a unique assemblage of benthic communities; 2) special commercial significance of a benthic community in a borrow deposit; 3) at locations where the benthic community is spatially limited with respect to recruitment and re-colonization; and 4) where the importance of a benthic community within the borrow area is significant for higher trophic levels or where this relationship is uncertain. In order to develop a layout of refuge areas that is practical and does not significantly influence the cost of the dredging operation, the type of dredging equipment and borrow deposit layout should be considered. Some specific dimensions for minimum feasible dredge areas are presented in the report as a guideline for developing a feasible layout of dredge and refuge areas. The MMS Plume model should be applied to determine the required size of the refuge areas considering the sedimentation footprint from the dredging operations. This proposed approach should be field tested along with a technique to monitor the effectiveness.

A blanket maximum pit depth rule is inappropriate. However, it is appropriate to determine a local maximum pit depth to avoid development of a mud cover and/or anoxia. The minimum practical pit depth would be greater than 1 m from Trailing Suction Hopper Dredges and greater than 2 m for Cutter Suction Dredges. Maximum pit depths should be determined on a site-specific basis through analysis combined with monitoring where necessary. Monitoring may assist the development of an appropriate maximum pit depth at borrow deposits that are dredged more than once.

It is likely only appropriate to consider the implementation of these measures at locations where there is nearby habitat that is sensitive to sedimentation, such as hard/live bottom areas or coral habitat with specific sedimentation sensitive organisms. In these cases, there is a need to establish field-tested sedimentation limits for different types of sensitive habitat. A blanket buffer zone width for all locations is probably unjustified. Another way of defining acceptable site-specific sedimentation levels, that may be more expedient, is through the monitoring of natural sedimentation rates. Once sedimentation limits are established for the local sensitive habitat, the best approach would consist of a pre-dredging assessment of the plume sedimentation footprint using the MMS Plume model (or equivalent), followed by real-time or near real-time monitoring of sedimentation levels. Turbidity monitoring may also be helpful to validate the Plume model, however, it is not a suitable replacement for direct monitoring of sedimentation. It would be appropriate to require the Anti-Turbidity valve device at locations where restricting the sedimentation footprint is important. At almost all locations the Green Pipe approach (where the overflow water is re-circulated to the draghead) is likely unjustified. At borrow sites with strong tidal currents or steep slopes, the possibility of the development of a near-bed turbidity current generated through the pancaking effect of the dynamic plume phase should be evaluated.

It is generally viewed that elevated levels of turbidity generated from Trailing Suction Hopper Dredge operations in open ocean waters does not represent a significant ecological impact. It is believed that adult fish can avoid plumes and that other organisms can survive the sub-lethal levels of short-term elevated turbidity. A one-size-fits-all limit of 29 NTUs above background levels measured at 150 m from the dredging operation is probably scientifically unjustified for the ocean environment. Nevertheless, representatives of the dredging industry that attended the study workshop indicated that the 29 NTU limit was not difficult to achieve. At locations where a more scientifically justified level is required, for example where there is a specific ecological concern about turbidity levels, it may be possible to develop a site-specific limit based on measurements of turbidity levels over a minimum period of one or two years. The Anti-Turbidity valve device is widely applied in the US and significantly reduces the size of plumes from Trailing Suction Hopper Dredges and the total sediment overflowed in the discharge process. It would be appropriate to require the use of this device wherever turbidity is a concern. The "Green Pipe" approach consisting of re-circulation of the overflow water to the draghead eliminates the plume above 4 to 5 m above the seabed (i.e. outside of the region of the draghead plume), but it does not reduce the total sediment discharged in the overflow process. However, this approach is not included on any US dredge vessels (nor on most European vessels) and would represent a significant and expensive equipment overhaul that would be passed on to the consumer through higher unit prices and is likely unjustified at most locations.

There is much to be learned about the processes that maintain the form of shoals, and therefore, the potential impacts of dredging sand from these features. Hayes and Nairn (2004) have summarized the literature on this topic and suggested a new mechanism for the maintenance of OCS shoals, however, the understanding of these features requires more investigation. This understanding and the development of guidelines for the removal of sand through dredging (specifically, how much and where) will require several lines of investigation including: a review of shoal morphometrics (as C. Spaur of the USACE, Baltimore District has initiated); an investigation of the sedimentology and stratigraphy of these features; and numerical modeling of waves, sediment transport and morphodynamics.

Study Products: W.F. Baird & Associates Ltd. and Research Planning Inc. 2004. Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies. U.S. Department of the Interior, Minerals Management Service, Sand and Gravel Unit, Leasing Division, Herndon, VA. OCS Report MMS 2004-XXX, XX pp. + appendices.